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# Track Time and Monetary Costs of Transportation as a Comprehensive Performance Measure: Development and Application of Transportation Cost Index

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# Tracking time and monetary costs of transportation as an accessibility measure: Development and application of Transportation Cost Index

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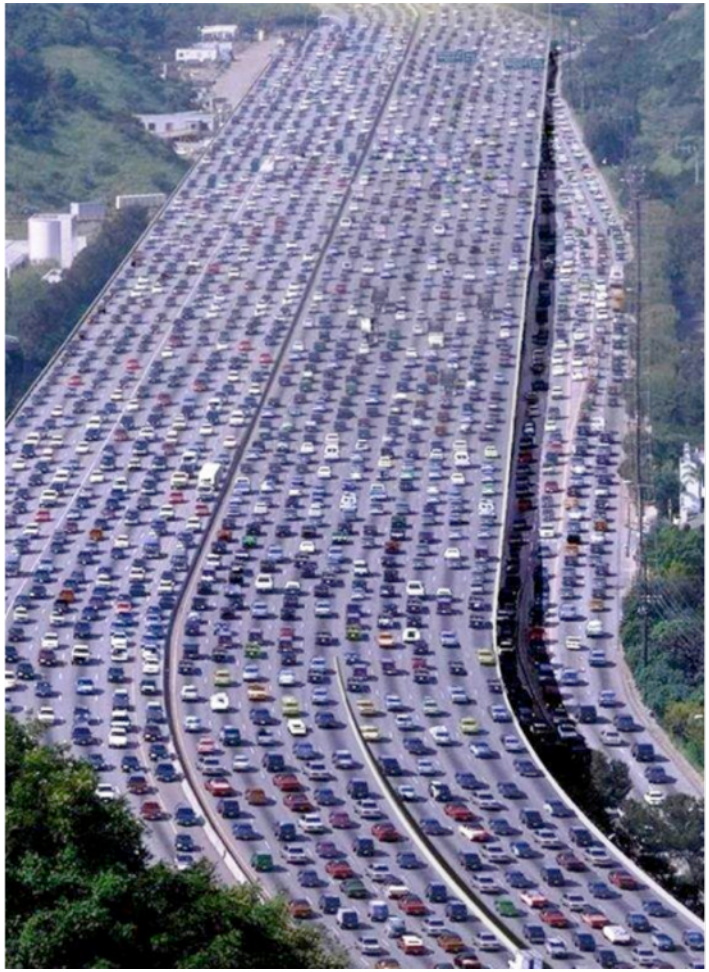
Bud Reiff (Metro), Brian Gregor (Oregon System Analytics)

# Outline

- Why we need yet another performance measure (YAPM)?
- Transportation Cost Index: the idea and implementations
- Applications and Demonstration
- Conclusions

# Performance Measures: Mobility vs Accessibility




Credit: Paul Waddell

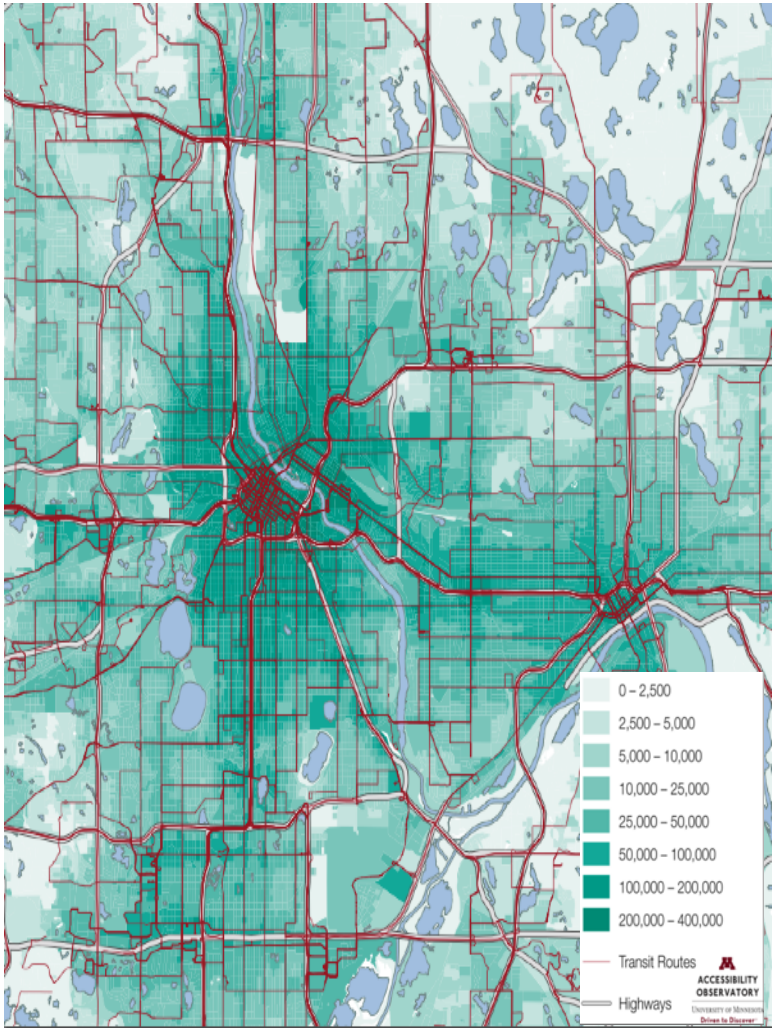
# Need for Accessibility Measures

- As a supplement/replacement of traffic-centric measures: LOS, travel delays/congestion
- MAP-21 emphasizes use of performance measures in transportation planning & operation
- State legislations: Oregon Job and Transportation Act (OJTA)

# Existing Accessibility Measures

- Handy and Niemeier, 1997
- Geurs and van Wee, 2004
- NCHRP Report 446, 618, 694, 708 ...

# Market Potential Measures




Employment accessible within 30 minutes by public transit during a.m. peak

- Easy to interpret/understand
- Opportunities, mode, time-of-day and time budget specific

Source: University of Minnesota, Accessibility Observatory

# Utility-based Measures

$$\mathrm{E(CS)} = \ln\left(\sum_{m'} \exp\left(U_{m'kj}\right)\right) + C$$

Logsum as an accessibility measure

- An Elegant, composite measure for all modes; possible to derive net user benefit between scenarios
- Hard to interpret by itself; unable to compare across regions/times (benchmarking)

# Generalized Costs Indicator

**Table 4**
Generalised costs indicator, for private car, 2007 (2000=100) by type of trip.

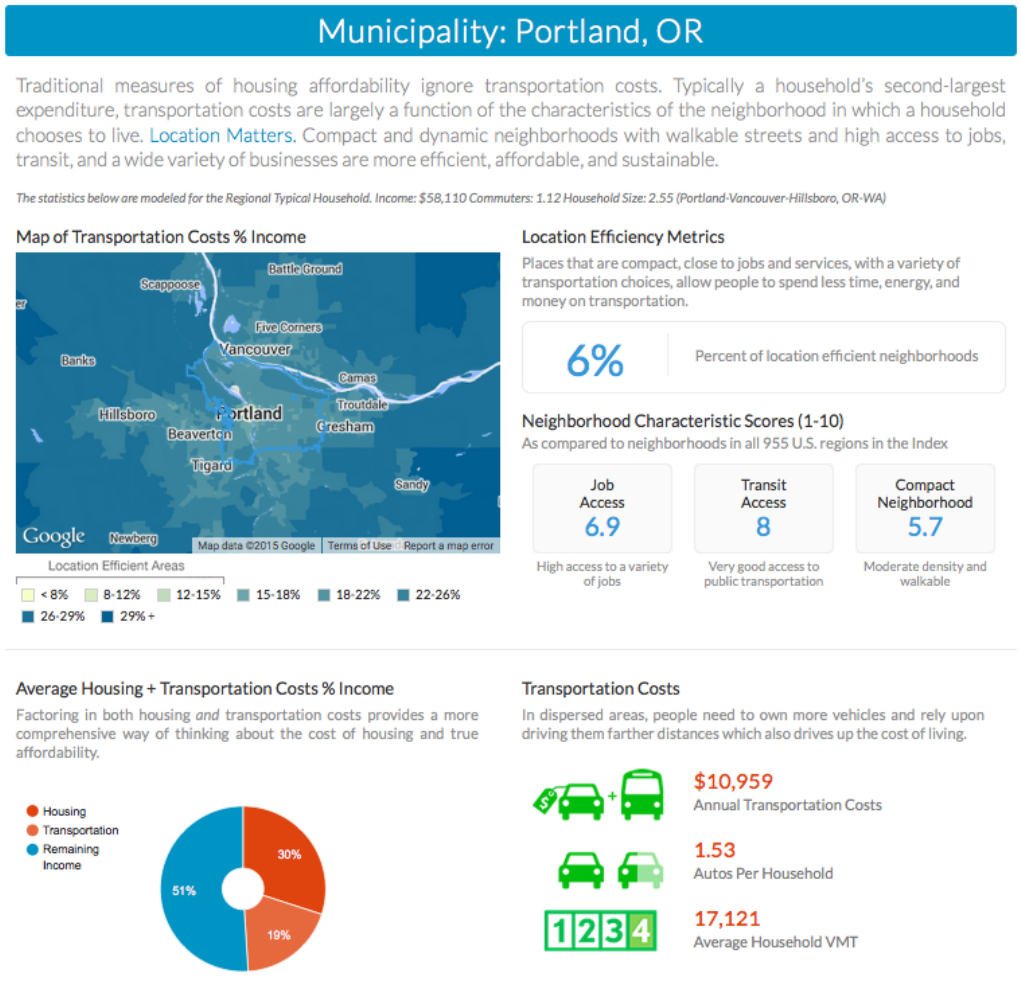
| | | |
|---|---|---|
| Location: | Randstad | 107 |
| | Outside Randstad | 105 |
| Time of day | Rush hour | 109 |
| | Outside rush hour | 105 |
| Trip purpose | Business | 102 |
| | Commuter | 110 |
| | Other | 106 |
| Distance (km) | Up to 15 | 105 |
| | 15 to 30 | 110 |
| | 30 to 50 | 108 |
| | More than 50 | 104 |

Per distance generalized costs for motorized trips

- Easy to interpret/ understand; able to monitor trends and compare scenarios
- ignores land use system; mode, time-of-day specific

Source: Koopmans, et al, 2013

# H+T® Affordability Index




- Tracks out-of-pocket monetary costs of transportation and adds them to housing costs as a location efficiency measure;
- Ignores time costs; not track the performance of transportation system except for Auto/Transit mode split and VMT.

Source: Center for Neighborhood Technology (CNT)

# Wish List for YAPM

- A comprehensive measure able to present an overall picture of transportation and land use;
- Fill gaps in policy areas not adequately covered by existing performance measures, such as the equity and compatibility aspects (Reiff and Gregor, 2005)
- Easy to interpret/understand;
- Applicable to use cases ranging from prioritization, scenario evaluation/comparison, to benchmarking and standard;

# Applicability of Performance Measures

| Application | Prioritization | Comparison | Long-term Benchmark | Near-team Standard or Threshold |
|---|---|---|---|---|
| Transportation System Planning / Subarea Plans / Multi-jurisdictional Corridor Planning | TCI | | | |
| Project / Corridor Planning | | | | |
| Plan Amendments / Zone changes subject to TPR | | | | |
| Development Review | | | | |

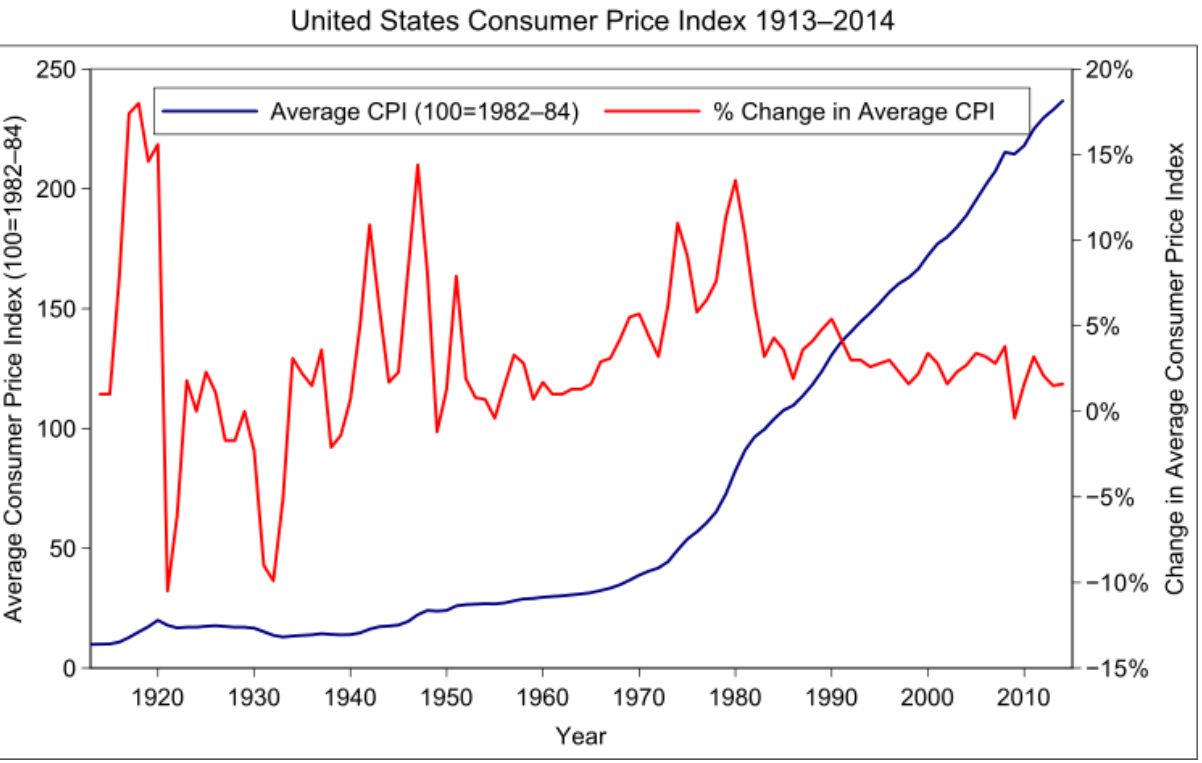
Selection Criteria:

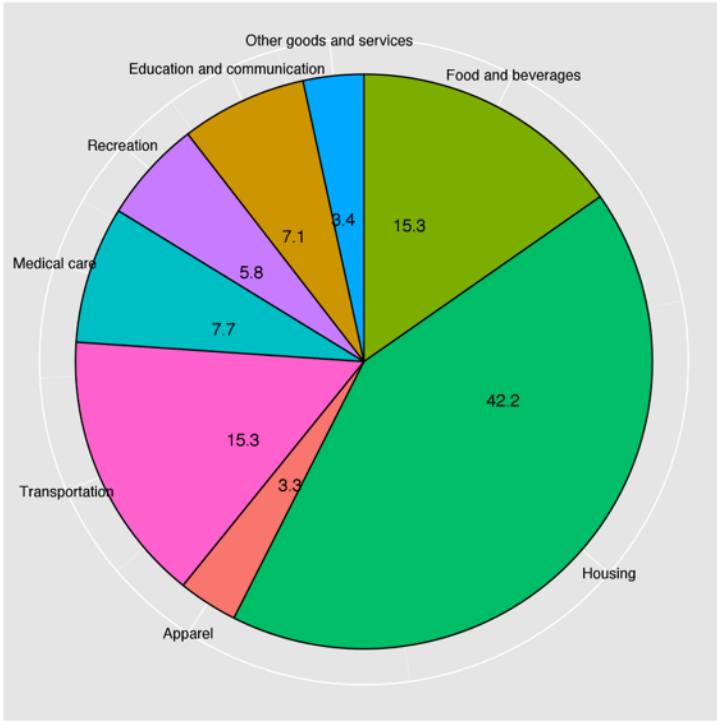
- Easy to apply
- Objective quantitive measure
- Good data availability
- Easy to understand

Source: Kittleson & Associations, Washington County Multimodal Performance Measures and Standards

# TCI: the idea and implementations

# Consumer Price Index (CPI)



# From CPI to Transportation Cost Index (TCI)

Measures changes in the “price level” of a market basket of trips/destinations meeting households’ daily needs:

1. Identify a basket of trips/destinations based on pre-defined groups (e.g. trip purpose categories);
2. Track the time and monetary costs of accessing trips/destinations in the basket.

# Transportation Cost Index (TCI)

- Comprehensive measure of transportation and land use;
- Able to serve as a performance measure for policy areas including equity, transportation and land use compatibility and balance;
- Easy to interpret/understand;
- Based on widely available data sources, possible for all types of applications, esp. benchmarking and scenario evaluation/ comparison

# Implementation A: Travel Survey-based Method

Relies primarily on input from household activity survey, e.g. Oregon Travel & Activity Survey (OTAS)

1. Construct travel baskets based on activity diaries or a sample of trips/tours that are representative of regional travel pattern, potentially by trip purpose, household size, income group and geography;
2. Track the time and monetary costs of making these trips/tours.

Suitable for prioritization and benchmarking applications.

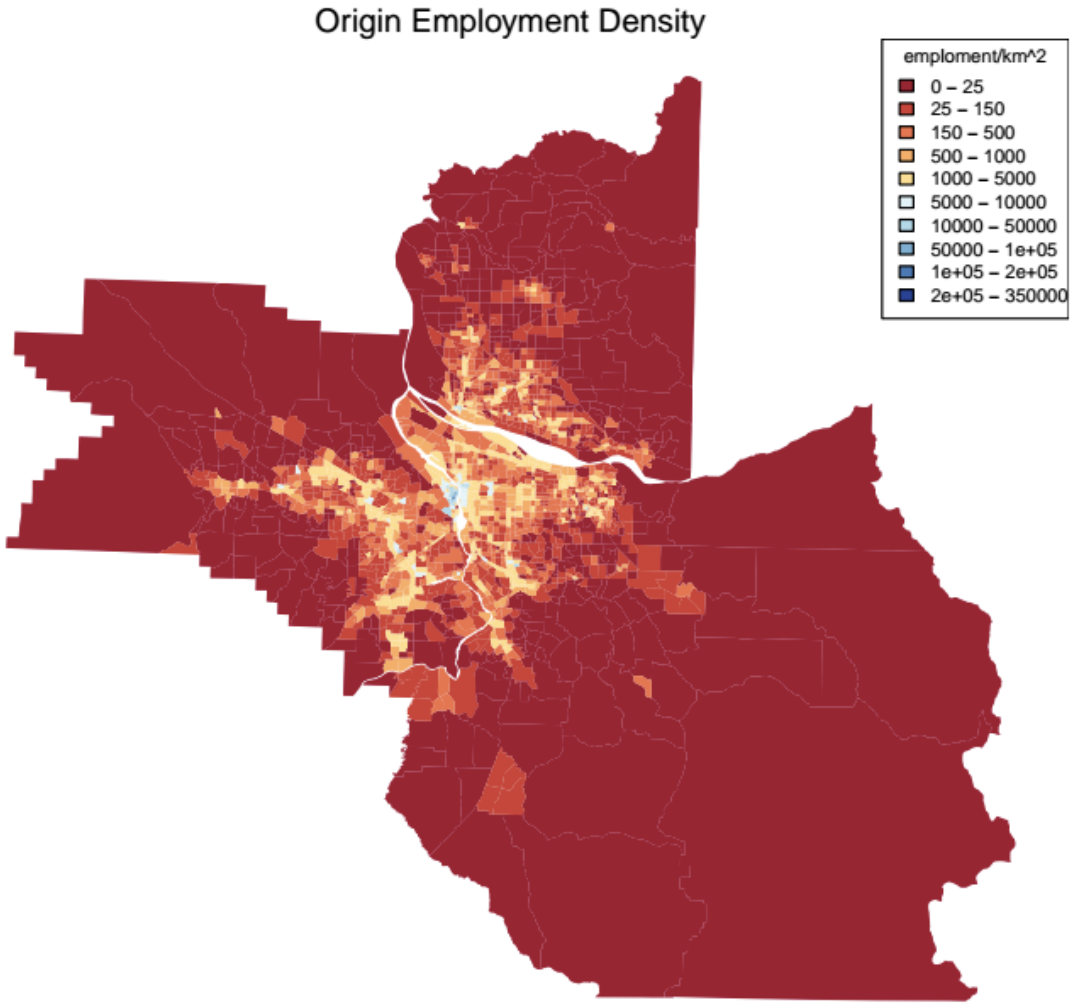
# Implementation B: TDM-based Method

Relies on inputs from travel demand model

- Data readily available for regions w/ TDM;
- Theoretically can calculate the transportation cost for every income group and for every TAZ;

Suitable for scenario evaluation/comparison.

# Implementation B: TDM-based Method



# Calculate Travel Costs: Cost Estimate by Mode

$$C = C_0 + k \cdot TD + w \cdot TT$$

$C_0$ - Constant

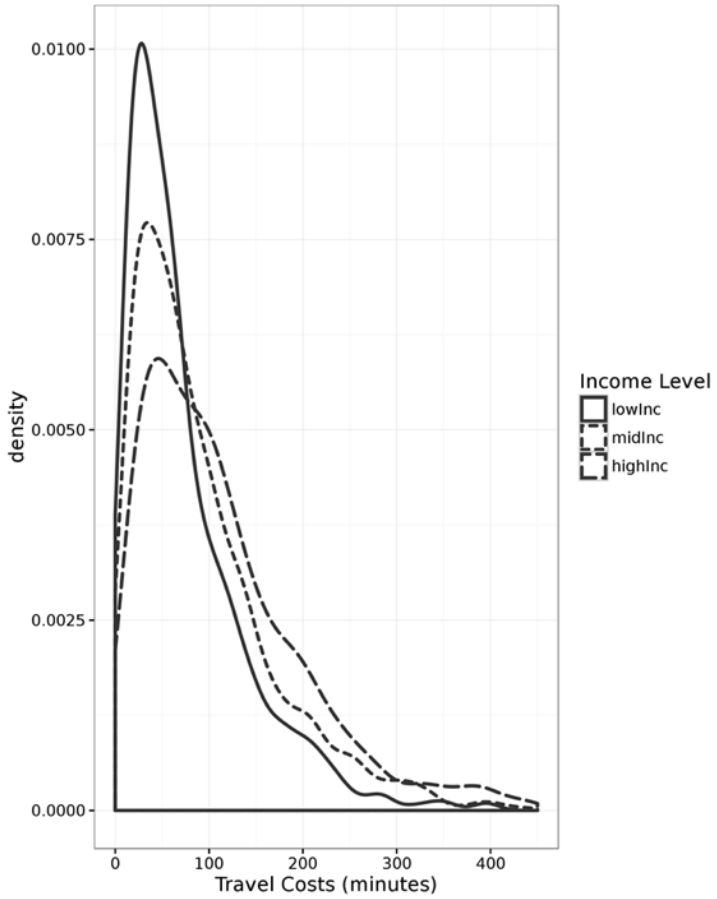
$k \cdot TD$ - Monetary costs (Fuel and tire costs, Ownership costs, insurance, etc) of travel

$w \cdot TT$ - Time costs of travel

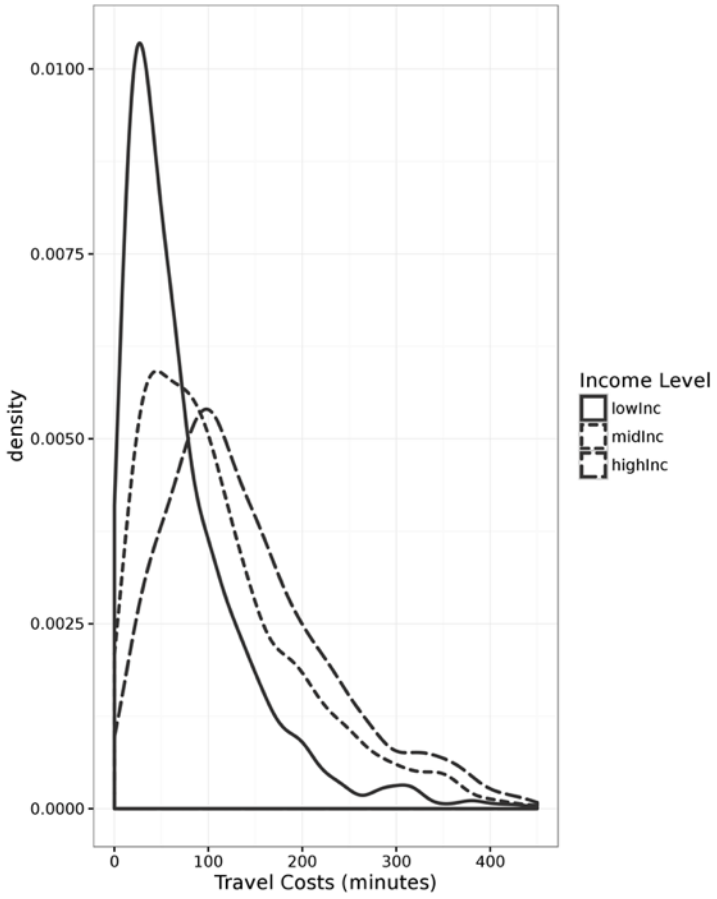
# Applications and Demonstration

# Generalized Costs by Household Income Level (Portland)

1994

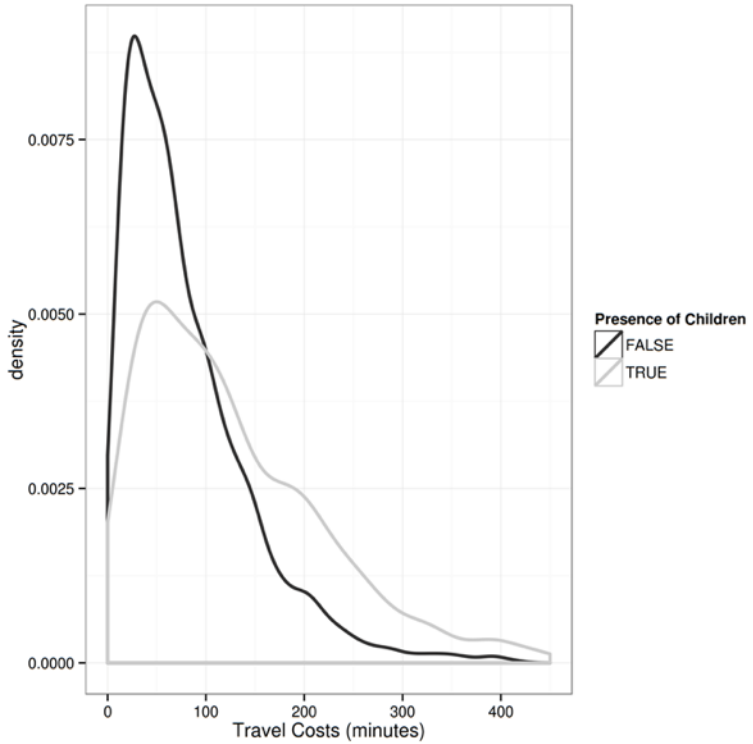



2011

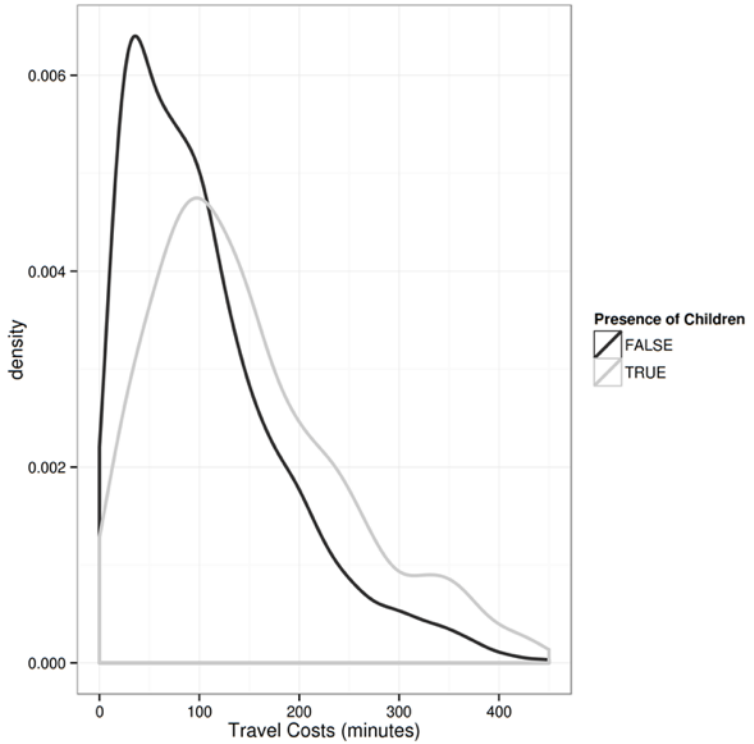


# Generalized Costs by Presence of Children (Portland)

1994

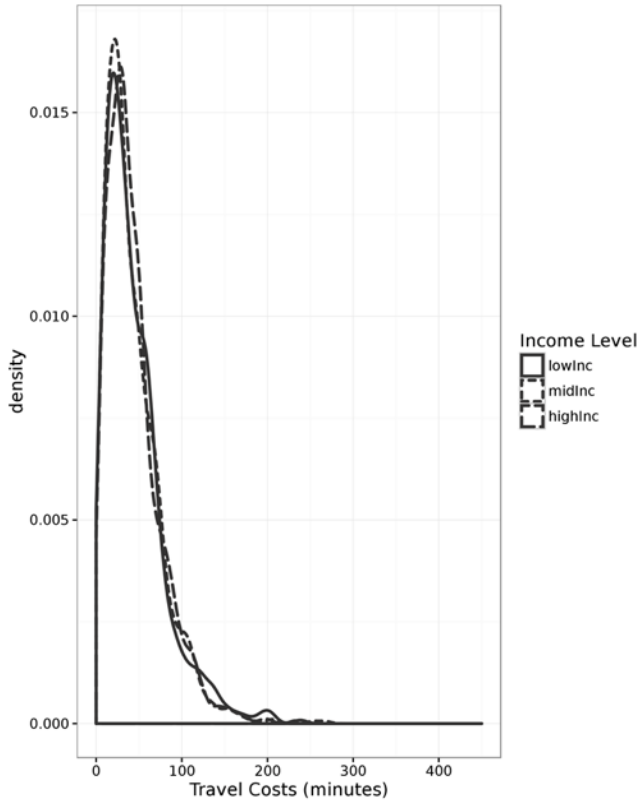



2011

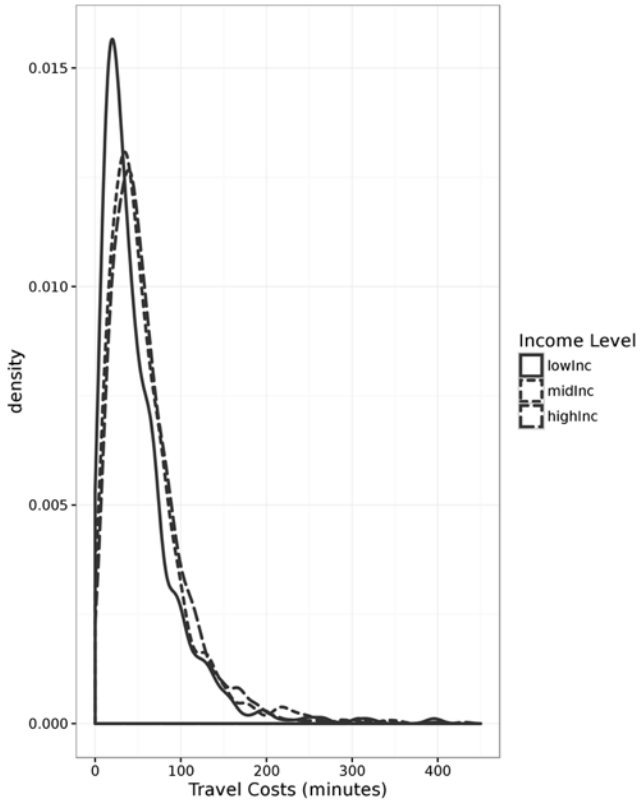


# Per Person Generalized Costs by Household Income (Portland)

1994

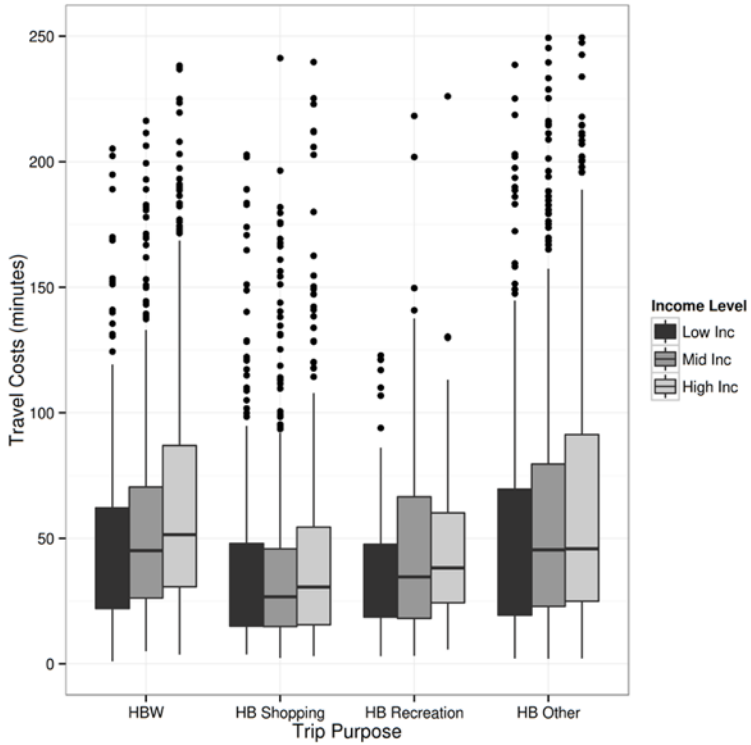



2011

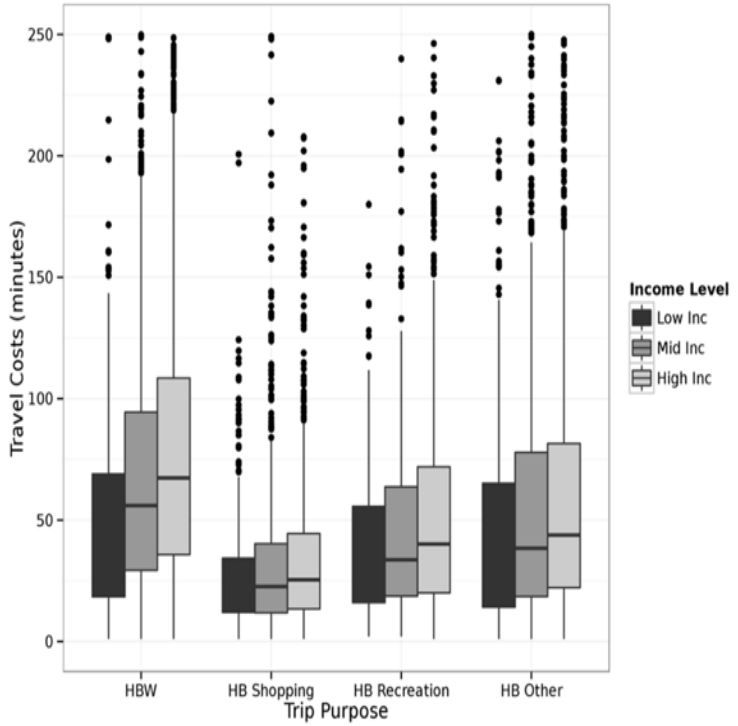


# Generalized Costs by Purpose and Income Level (Portland)

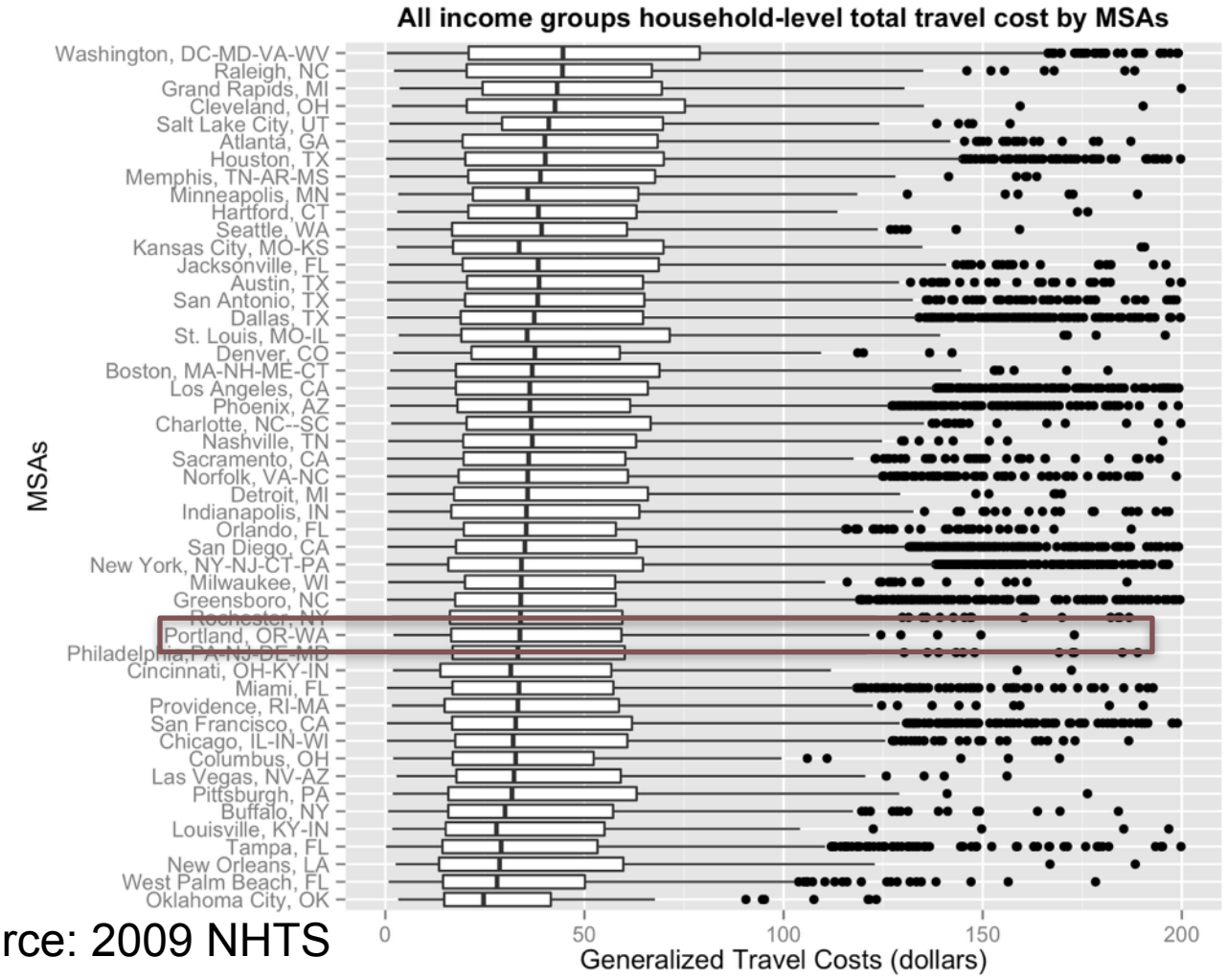
1994




2011

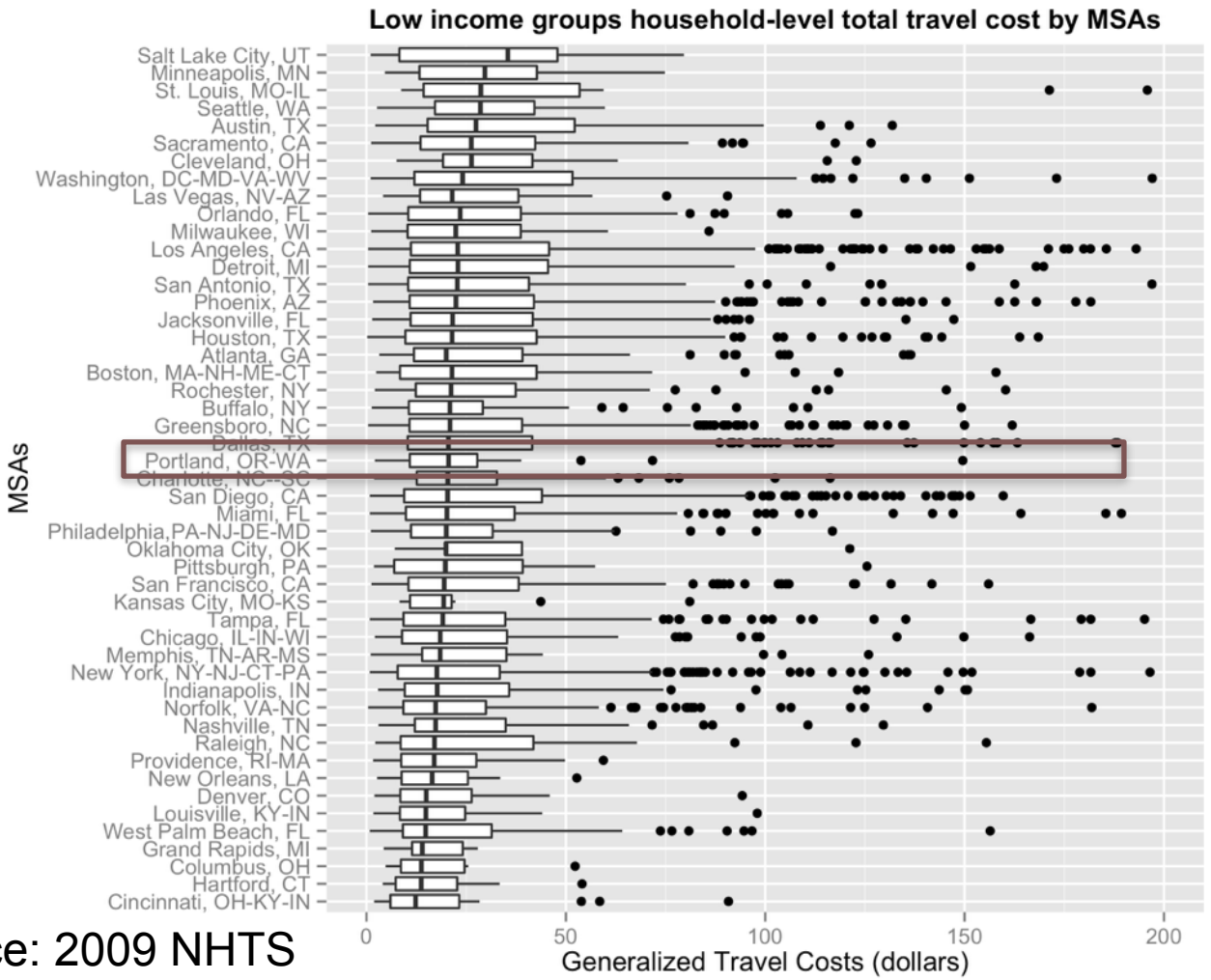


# Transportation Costs by MSA (All households)



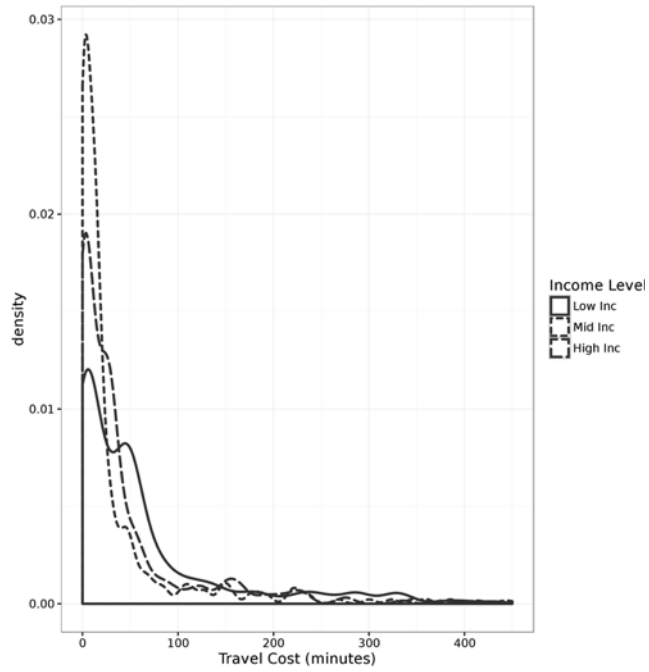

Data source: 2009 NHTS

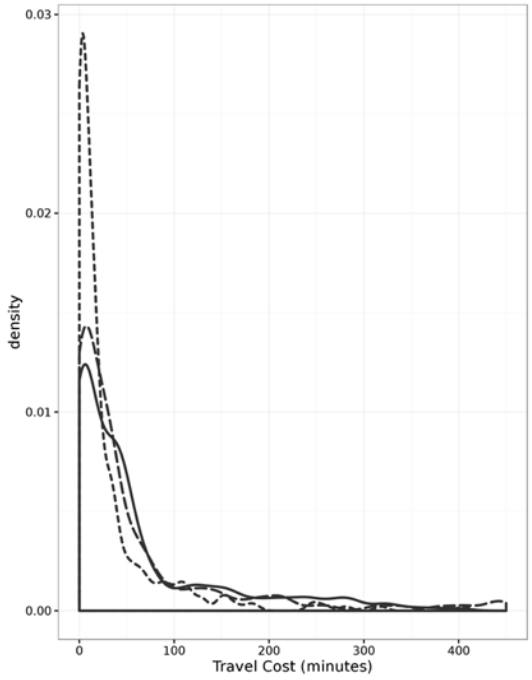
# Transportation Costs by MSA (Low Income)

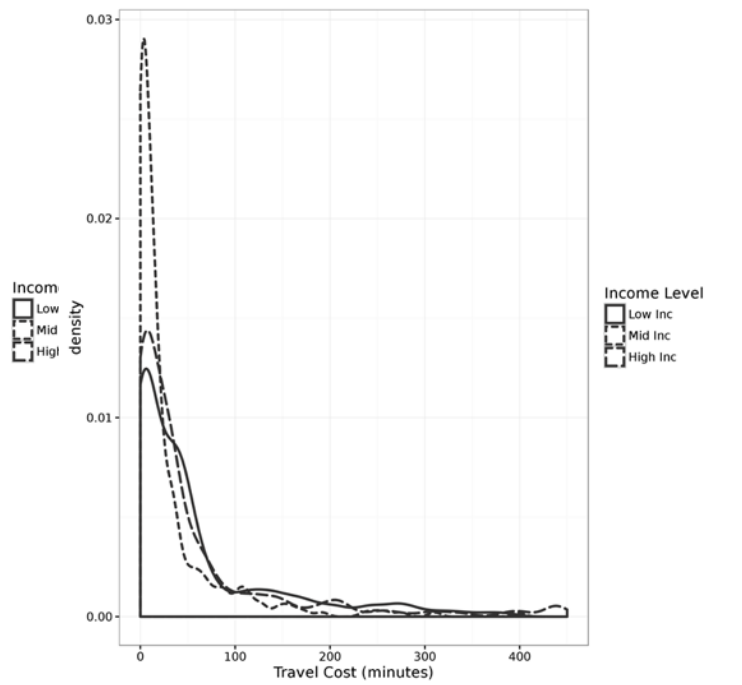



Data source: 2009 NHTS

# Generalized Costs by Income Level (Corvallis)

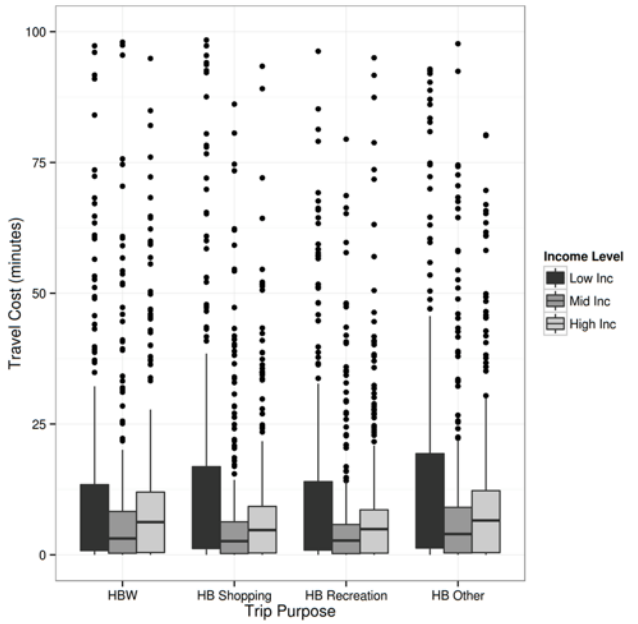


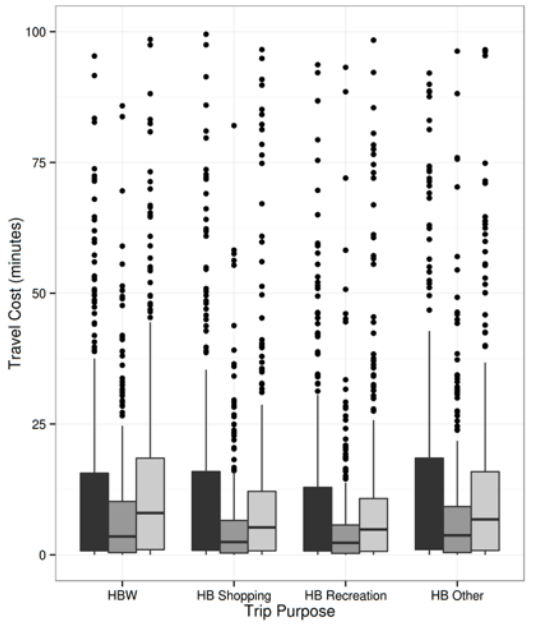




2010 2030 Preferred 2030 Preferred Scen1

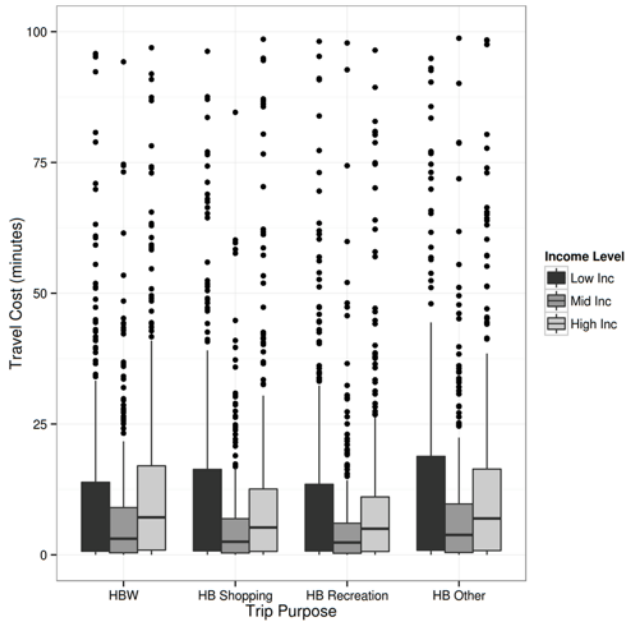
# Generalized Costs by Trip Purpose and Income Level (Corvallis)




2010

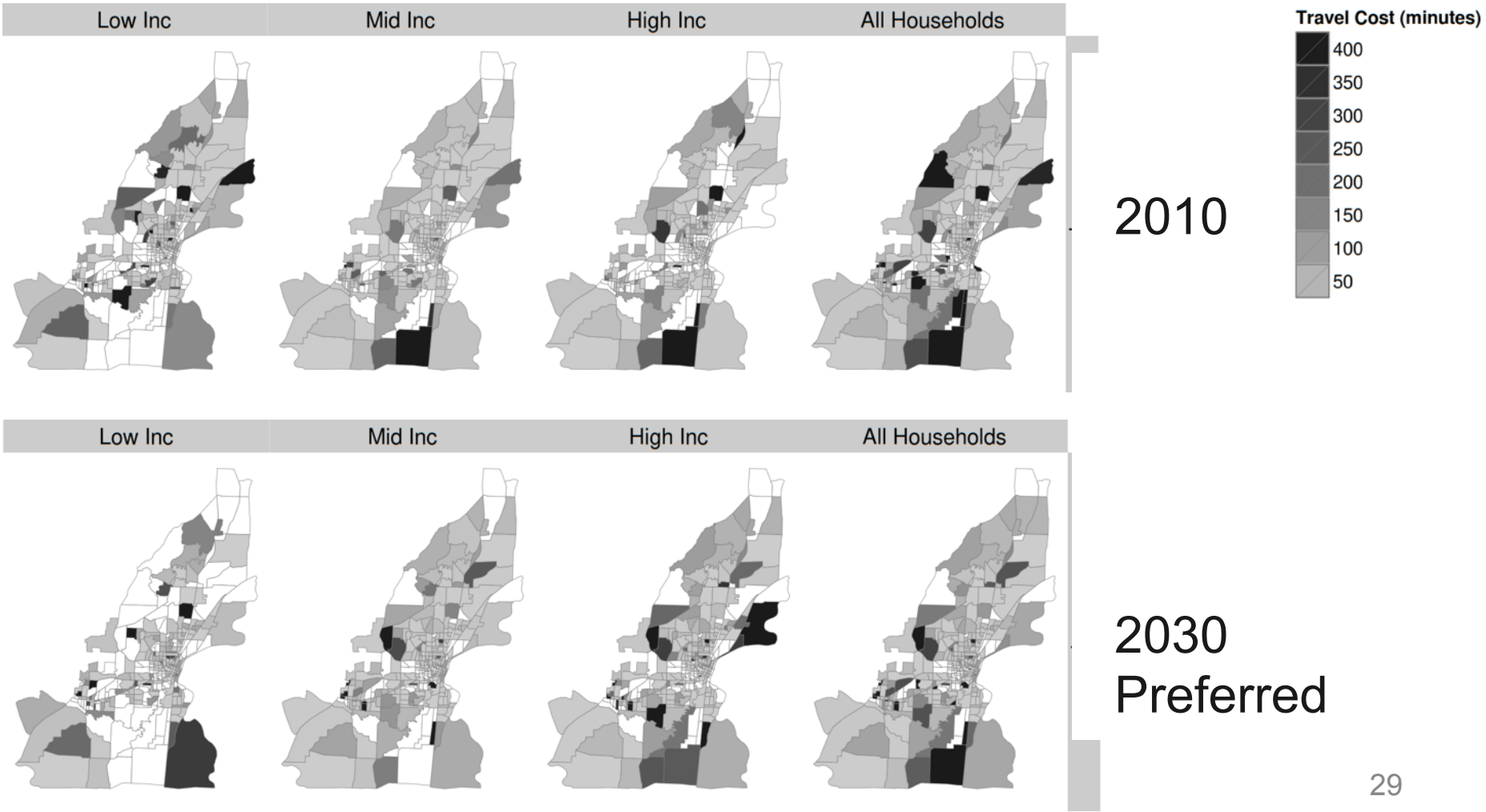



2030 Preferred




2030 Preferred Scen1

# Generalized Costs by Income Level (Corvallis)



# Ongoing and Future Work

- Adopted by the Accessibility Indicator Development Team (IDT) as one of indicators for the Oregon Mosaic project mandated by OJTA
- Test TCI usage in public engagement and policy making process
- Reconcile TCIs from the two methods;
- Verify patterns of transportation costs with information from alternative data sources, such as CES.

# Code and Working Papers

- Code (under active development/testing) available at http://github.com/cities-lab/tci
- Working Papers:

1. Wang, Liming, Bud Reiff, Brian Gregor, Huajie Yang, and Jenny Liu, 2015. Transportation Cost Index: A Comprehensive Multimodal Performance Measure of Transportation and Land Use Systems, presented at the 94th Annual Meeting of Transportation Research Board, Washington, DC, January 11-15, 2015.
2. Wang, Liming, Huajie Yang and Jenny Liu, Transportation Cost Index as a Performance Measure for Transportation and Land Use Systems: New Approaches and Application in Portland, OR, presented at the 95th Annual Meeting of Transportation Research Board, Washington, DC, January 10-14, 2016.

# Acknowledgements


National Institute for Transportation and Communities


Oregon DOT

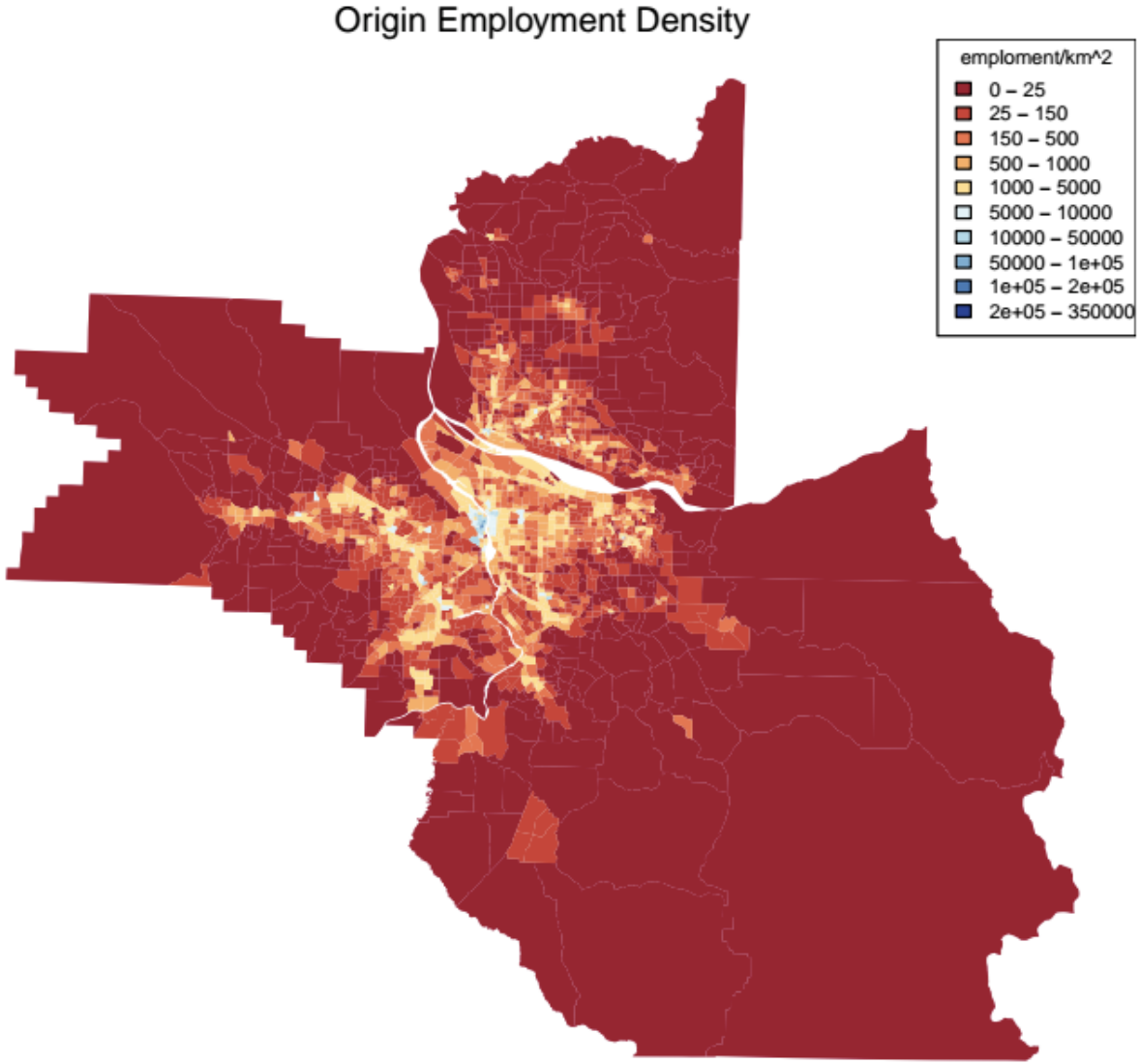
# Extra Slides

# Income Levels

To be consistent with the classification used in Metro's TDM, household income levels are classified with this scale (1994 dollars):

- < $25K: Low Income
- $25-50K: Mid Income
- > $50K: High Income

# Identify Activity Centers (Travel Market Basket)



# Steps (Giulinao, 1991)

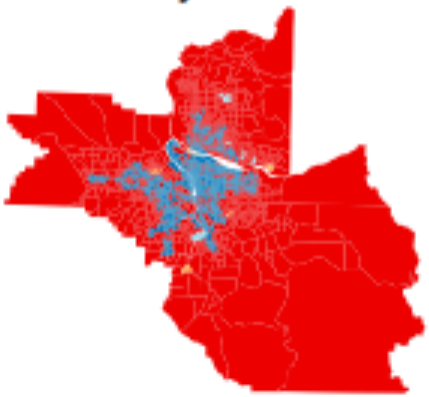
1. Calculate employment/size term density;
2. Identify TAZs with densities greater than density cutoff D and group contiguous TAZs identified into preliminary centers;
3. Calculate total employment or size terms for each center identified in step 2 and eliminate centers with total employment or size terms below total cutoff E from centers identified in step 2. The remaining are activity centers.

# Determine Cutoffs

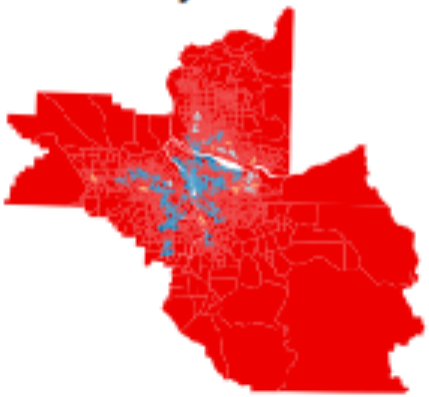
- Giulinao (1991) provides no guidance in selecting density cutoff (D) or total cutoff (E). They relied on expert knowledge
- Sensitivity Tests to determine cutoffs

# Sensitivity Tests: HBW

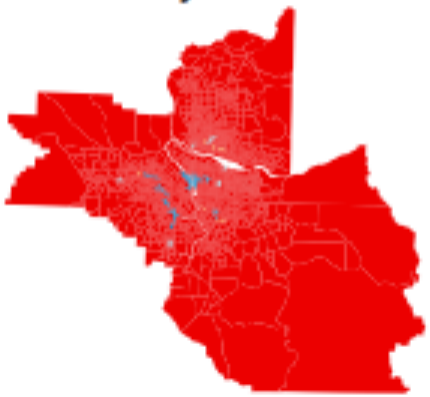
Density cutoff 50



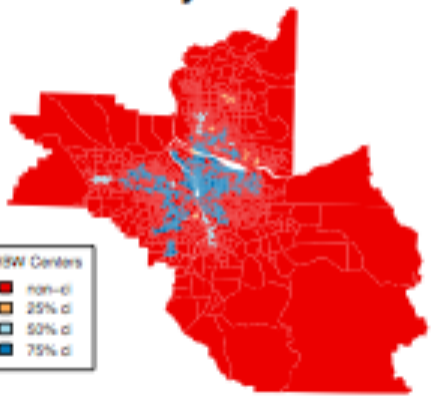
Density cutoff 70



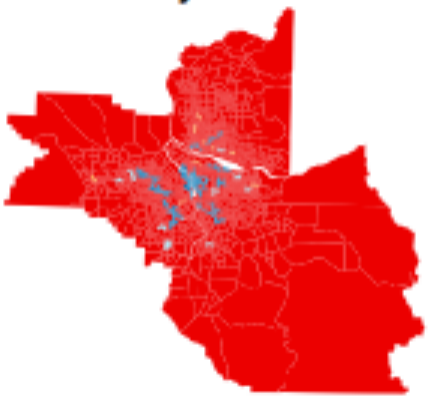
Density cutoff 90



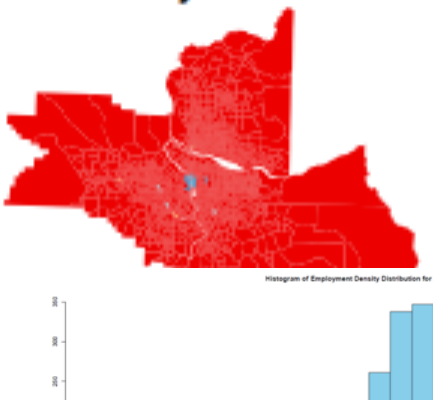
Density cutoff 60

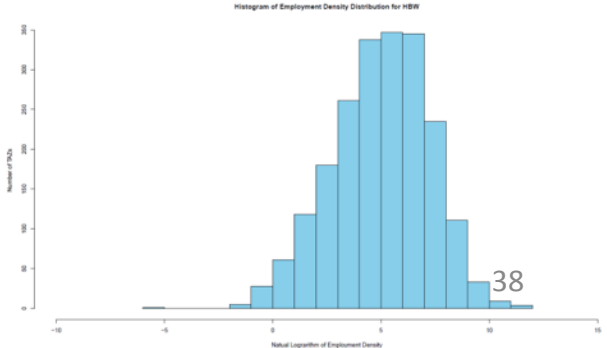



Density cutoff 80



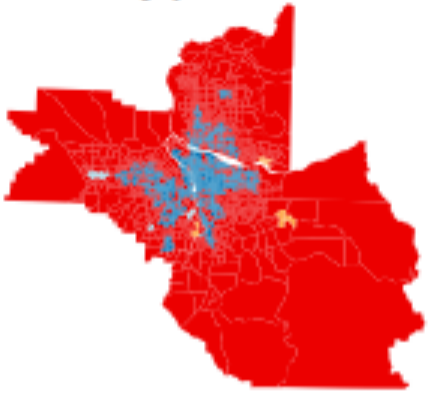
Density cutoff 95



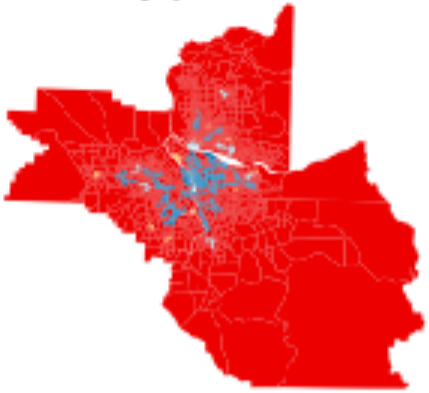


# Sensitivity Tests: HBS

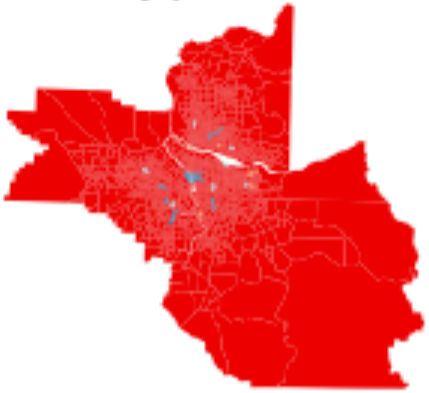
Density percentile 50



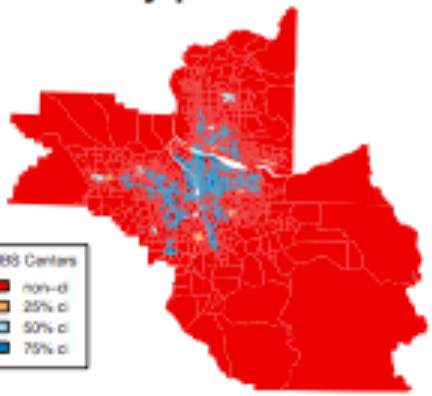
Density percentile 70



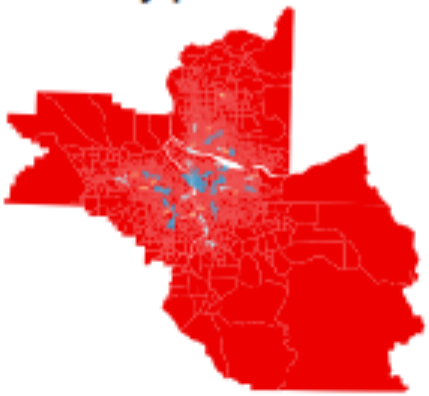
Density percentile 90



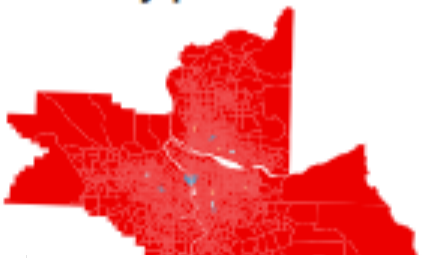
Density percentile 60

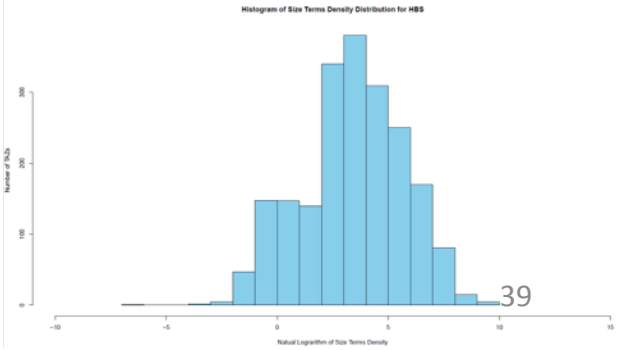



Density percentile 80



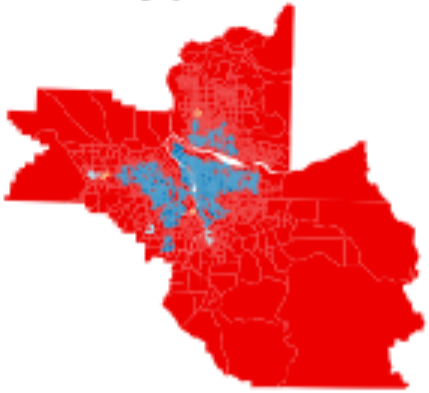
Density percentile 95



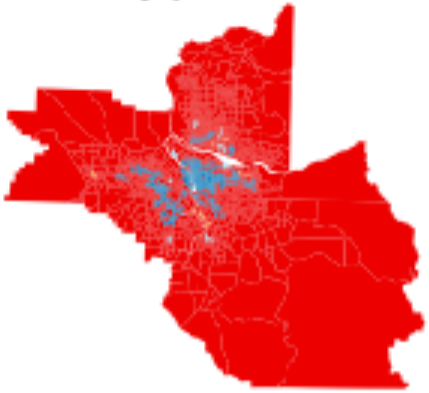


# Sensitivity Tests: HBS

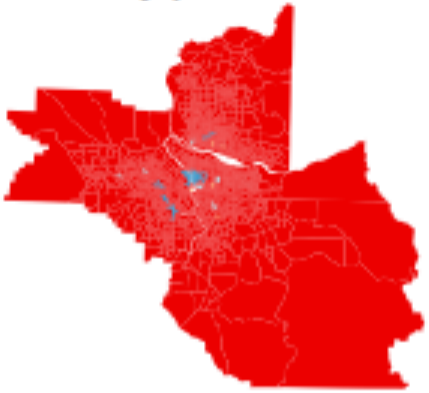
Density percentile 50



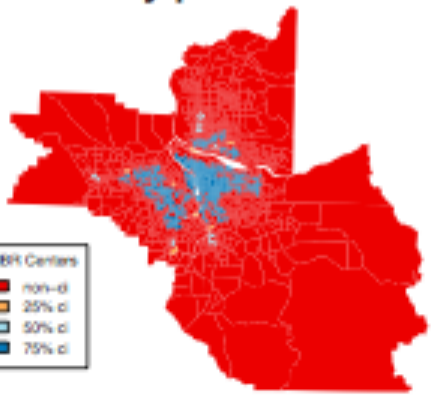
Density percentile 70



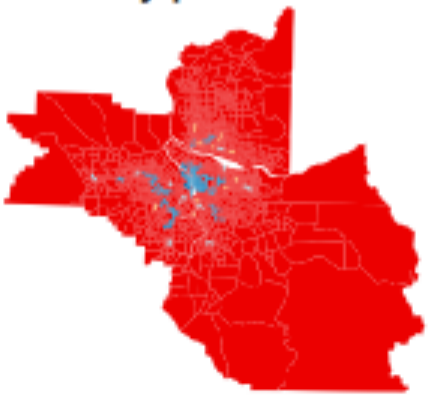
Density percentile 90



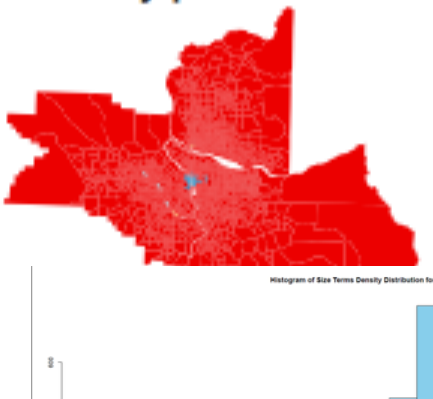
Density percentile 60

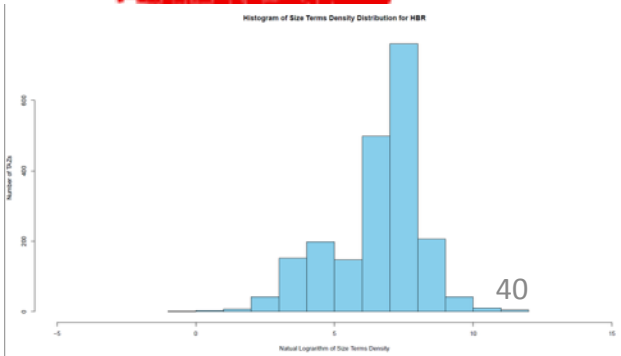



Density percentile 80



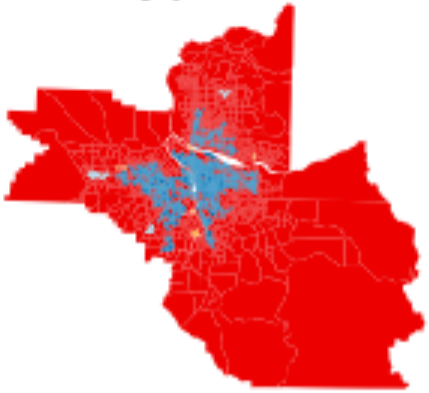
Density percentile 95



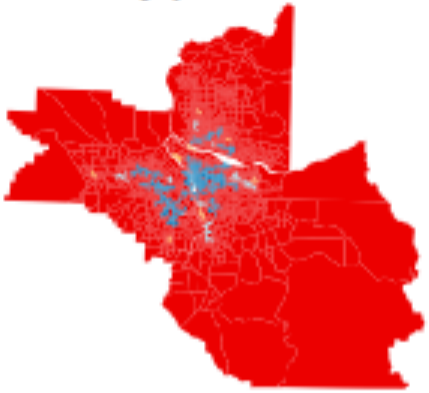


# Sensitivity Tests: HBO

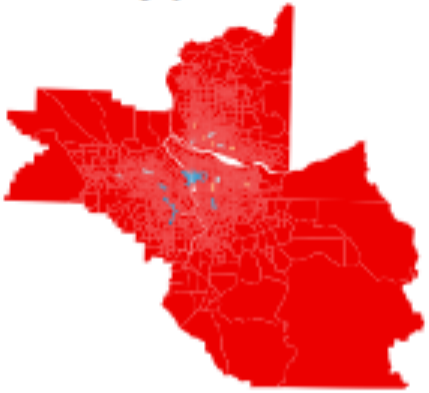
Density percentile 50



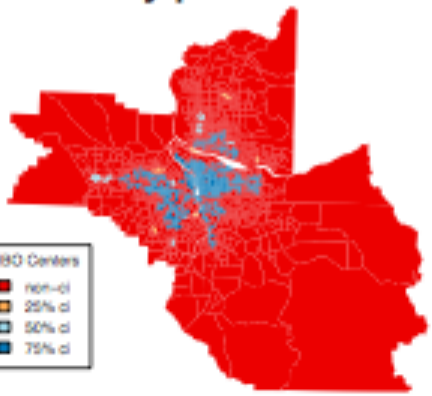
Density percentile 70



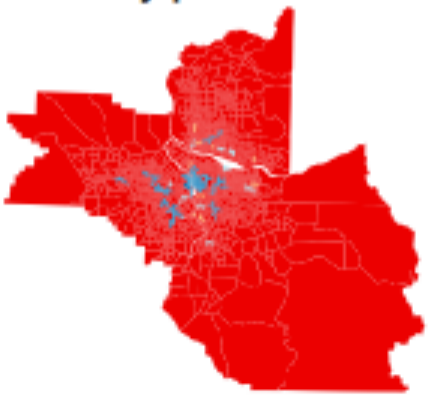
Density percentile 90



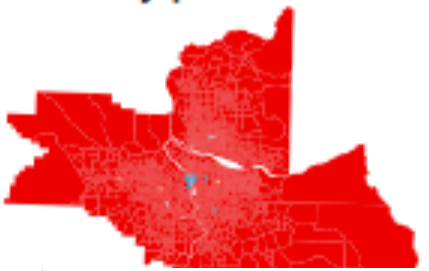
Density percentile 60

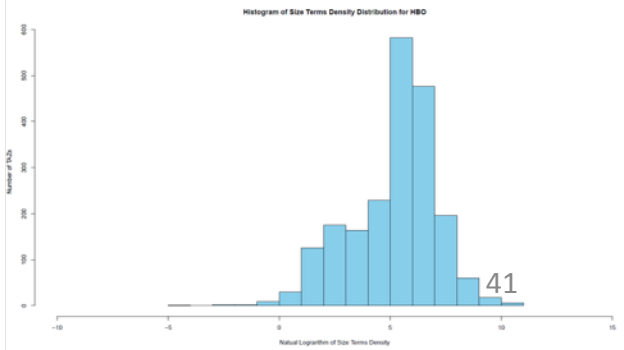



Density percentile 80



Density percentile 95





# Travel Costs Calculation: Cost Estimate by Mode

- Auto

$$C_{auto} = C_{auto0} + k_{auto} \cdot TD_{auto} + w_{auto} \cdot TT_{auto}$$

  - $C_{m0}$ - Constant
  - $k_{auto} \cdot TD_{auto}$ - Monetary costs (Fuel and tire costs, Ownership costs, insurance, etc) of driving
  - $w_{auto} \cdot TT_{auto}$ - Time costs of driving

# Travel Costs Calculation: Cost Estimate by Mode

- Public Transit:

$$C_{public} = \text{fare} + w_{public} \cdot TT_{public}$$

  - Fare: Transit fares
  - $w_m \cdot TT_{public}$: Time costs of riding transit

- Non-motorized modes (bicycling and walking)

$$C_{bicycle} = C_{bicycle0} + w_{bicycle} \cdot TT_{bicycle}$$

$$C_{walk} = w_{walk} \cdot TT_{walk}$$

  - Time costs of Bicycling and Walking

# Parameters

**VOT (ratio to hourly wage):**
walk=0.5 bike=0.5
auto / van/ truck driver=0.5
auto / van / truck passenger=0.35
bus=0.35 rail=0.35
dial-a-ride/paratransit=0.35
taxi=0.35 school bus=0.35
carpool / vanpool=0.35
other (specify)=0.5
driveAlone=0.5
drivePass=0.5
pass=0.35 busWalk=0.35
parkAndRideBus=0.35

**Monetary costs per mile:**
walk=0 bike=0
auto / van/ truck driver=$0.592
auto / van / truck passenger=$0.592
bus=$1.01 rail=$1.38
dial-a-ride/paratransit=0
taxi=$2.6 school bus=0
carpool / vanpool=0
other (specify)=$0.296
driveAlone=$0.592
drivePass=$0.592
pass=$0.592 busWalk=$1.01
parkAndRideBus=$1.01